



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁴ : C02F 1/52		A1	(11) International Publication Number: WO 88/ 0092
			(43) International Publication Date: 11 February 1988 (11.02.88)
(21) International Application Number: PCT/GB87/00549		(72) Inventors: CONNAUGHTON, Noel ; Tobervaddy Athleague, Co. Roscommon (IE). POHORESKI, Arton ; 149 Jessop Avenue, Saskatoon, Saskatchewan S7N 1Y3 (CA).	
(22) International Filing Date: 3 August 1987 (03.08.87)		(74) Agent: BANNERMAN, David, Gardner; Withers Rogers, 4 Dyer's Buildings, Holborn, London EC1A 2JT (GB).	
(31) Priority Application Numbers: 892,831 1133/87 1134/87		(81) Designated States: AT (European patent), AU, BE (European patent), BR, CH (European patent), DE (European patent), DK, FI, FR (European patent), G (European patent), IT (European patent), JP, KR, LI (European patent), NL (European patent), NO, S (European patent).	
(32) Priority Dates: 4 August 1986 (04.08.86) 7 May 1987 (07.05.87) 7 May 1987 (07.05.87)			
(33) Priority Countries: US IE IE			
(71) Applicant: CONTINENTAL MANUFACTURING & SALES INC. [CA/CA]; 149 Jessop Avenue, Saskatoon, Saskatchewan S7N 1Y3 (CA).		Published With international search report.	
(54) Title: METHOD FOR THE TREATMENT OF SEWAGE AND OTHER IMPURE WATER			
(57) Abstract			
<p>The method includes adding to the sewage or other impure water in a mixing zone, all three individually but not more than two premixed together of the following: (a) an inorganic coagulant, (b) an anionic polymer, and (c) a cationic polymer, with intimate mixing of the added chemicals with the sewage or other impure water, with the proviso that (d) the inorganic coagulant, either alone or with the anionic polymer or the cationic polymer, cannot be added last; and (e) the anionic polymer and the cationic polymer cannot be premixed and added together. This provides chemically-treated effluent having large, compact, firmly-bonded, substantially-shear resistant and rapidly-separable flocs therein. The flocs are separated from the liquid in a separating zone. Treated effluent is then removed from the separating zone. A predetermined amount of the treated effluent is then recycled back e.g. to the mixing zone, or another location determined by site trials.</p>			

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METHOD FOR THE TREATMENT OF SEWAGEAND OTHER IMPURE WATER

The present invention relates to a method for treating impure water, and more particularly to an improved method for treating sewage to produce treated effluent of very high quality.

It is known that color, turbidity, organic matter and similar impurities may be removed from water by coagulants, e.g. alum, ferric sulfate or the like. These compounds are acidic and react with the alkalinity in the water or with alkaline compounds, e.g. lime or soda ash, to form voluminous insoluble precipitates (hydrates). The precipitates have a tremendous surface area on which the dissolved or colloiddally dispersed impurities are absorbed. The suspended impurities are surrounded by the gelatinous hydrates and become part of the precipitate.

Domestic or sanitary sewage and industrial wastes may be purified by the chemical precipitation process, in which suitable chemicals (e.g. aluminum sulfate, lime, iron chloride, polyelectrolytes or combinations thereof) are added to the sewage and the sewage passed to one or more flocculating tanks, normally equipped with slowly rotating agitators or paddles, in which colloidal solids are formed into particles of size and weight that will settle. The colloidal solids or flocs are then separated from the liquid by being allowed to settle in subsequent settling tanks, whereafter the purified water is collected in a weir structure mounted at the surface of the water, while the sediment, consisting of flocs and sludge, is removed, normally by means of sludge scrapers

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and/or pumps.

The prior art teaches the addition of various types of chemicals and combinations of chemicals to sewage and other impure water to remove various pollutants therefrom.

There are several deficiencies in the prior art which the present invention overcomes as indicated below:

1. The invention, when used to treat raw sewage or other impure water with very economical doses of three chemicals converts a very high proportion of the suspended, colloidal and dissolved pollutants in the sewage or other impure water to large, dense and stable flocs which are so resistant to shear forces they can be settled out in a clarifier without the aid of inclined sedimentation means, and with an upward flow velocity of at least eighteen to twenty meters per hour. This flow rate is approximately ten times higher than than recommended by those skilled in the art for clarifiers without inclined sedimentation means.

The foregoing is a very important advantage from an economic point of view because it allows the use of a very much smaller clarifier, and reduces the area of land required for a treatment plant.

2. The invention, notwithstanding the fact that very economical doses of chemicals are used and the floc is settled against an upward velocity flowrate of 18-20 m/hr. without inclined sedimentation means, achieves removal rates of pollutants which heretofore have not been possible as indicated hereunder:

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<u>Pollutant</u>	<u>Average % Removal</u>
Biochemical Oxygen Demand	76%
(BOD ₅) Dissolved BOD ₅ under 0.2 microns in size	32%
BOD ₅ over 0.2 microns in size	95%
Total phosphorus	97%
Turbidity	95%
Total Suspended Solids	92%
Fats, Oils and Grease	90%
Aluminum	Removes all of the aluminum which is dosed into the sewage or industrial effluent, in addition to approximately 70% of the small quantity of aluminum present in the influent.

3. The invention is a considerable improvement over the prior art in relation to the removal of Biochemical Oxygen Demand (BOD₅), with approximately 95% of all BOD₅ over 0.2 microns in size being removed, and in addition, almost one third of the BOD₅ less than 0.2 microns in size also being removed.

The implications of this fact means that the invention can be used in many locations to treat raw sewage to a standard that does not require further treatment before discharge to waterways, whereas the effluent from other chemical systems requires additional biological treatment.

Furthermore, where highly polluting waste waters are treated in accordance with this invention and where the resulting treated effluent requires additional biological treatment, the pollutional load on the subsequent biological system is reduced to a significant extent, thereby resulting in substantial cost savings.

4. When sewage or other impure water is treated using the methods described in this invention, the percentage removal of suspended solids and turbidity is significantly greater than can be accomplished by the prior art taking into account the dosage of chemicals and the flow rates through the clarifier.

This is a very important improvement over the prior art, and it eliminates the need for a subsequent filtration process in many instances.

It also allows the use of additional processes in many cases such as Ultraviolet Disinfection, Reverse Osmosis, Activated Carbon and/or Ammonia Removal using Clinoptilolite Ion Exchange Material without the use of an intervening filtration process.

Tests have indicated that raw sewage, after being treated using the methods described by this invention, and then passed directly through an ultraviolet disinfection apparatus, was efficiently disinfected and the resultant total coliform count was only 10 per 100 ml.

5. A very important advantage of this invention over the prior art is its versatility. The invention can be used as either a Primary and/or Secondary and/or Tertiary Treatment system, and can

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be combined to advantage with other chemical, physical or biological processes.

6. Another important advantage of this invention is the overall speed with which the treatment process takes place. While the overall retention time required is site specific and depends on such factors as the quality of the influent and/or the quality of the effluent required, typically, for sewage treatment the overall retention time is less than thirty minutes.

The system therefore easily lends itself to automation, which would have substantial economic advantages such as control of chemical dosages and reduction of labour costs.

7. The quality of the sludge produced by the use of this invention, while being site specific, is generally of a very high solids content and is readily thickened in a short period of time. The resulting thickened sludge is then readily dewatered to a high solids content cake. This is a very important aspect of this invention, and distinguishes this invention over the prior art in that the total volume of sludge to be disposed of is lower than usual, resulting in important economic and environmental advantages.

The invention provides a method for treating sewage or other impure water wherein the following three individual chemicals (but no more than two premixed together) are added to the sewage or other impure water in a mixing zone:

(a) an inorganic coagulant, (b) an anionic polymer, and (c) a cationic polymer, with intimate mixing of the added chemicals with the sewage or

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other impure water, with the proviso that (d) the inorganic coagulant either alone or with the anionic polymer or the cationic polymer cannot be added last; and (e) the anionic polymer and the cationic polymer cannot be intimately mixed and added together, thereby to provide chemically-treated effluent having large, compact, firmly-bonded, substantially shear resistant and rapidly separable flocs therein; separating the flocs from the liquid in a separating zone; and removing treated liquid effluent from the separating zone.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Predetermined amounts of three chemicals, one from each of the three broad generic groups namely, Inorganic Coagulants (i.e. aluminum sulphate, ferric chloride, Cationic Polymers, e.g. Polyelectrolytes, and Anionic Polymers, e.g. Polyelectrolytes are added to sewage or other impure water. The three chemicals are intimately mixed with the sewage or other impure water in a mixing/flocculation zone to form large dense flocs from the suspended, colloidal and dissolved pollutants in the sewage or other impure water, separating these flocs from the sewage or impure

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water in a separating zone, drawing of treated effluent from the separating zone, and recycling a predetermined amount of sludge from the separating zone to the mixing/flocculation zone. The dosages of chemicals, the sequence of addition, the specific chemicals used and the amount and location of sludge recycle are site specific and depend on design parameters such as:

1. The quality of the influent impure water to be treated;
2. The quality of effluent required or economic, and/or environmental and/or health criteria.

Extensive testing has been carried out using this process on raw sewage and on industrial-type effluent, and it has been discovered that there are certain combinations in which the three chemicals at economic dosage levels can give improved and unexpected results over the prior art, while other combinations using the same dosage levels give most unsatisfactory results under the same test conditions.

The following sequence of additions of the chemicals to the sewage of impure water are the ones to be employed to give the desired results:

1. All three chemicals added separately in the following sequence:

Inorganic Coagulant (A)
Anionic Polymer (C)
Cationic Polymer (B)

- 2) All three chemicals added separately in the following sequence:

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Cationic Polymer (B)
Inorganic Coagulant (A)
Anionic Polymer (C)

3) All three chemicals added separately in the following sequence:

Anionic Polymer (C)
Inorganic Coagulant (A)
Cationic Polymer (B)

4) An inorganic coagulant (A) and a cationic polymer (B) are mixed in the one container and then dosed into the sewage as a single mixture, intimately mixed with the sewage, and then anionic polymer (C) is dosed into the sewage.

5) An inorganic coagulant (A) and an anionic polymer (C) are mixed in the one container and then dosed into the sewage as a single mixture, intimately mixed with the sewage, and then cationic polymer (B) is dosed into the sewage.

In all cases (1) to (5), the amount of inorganic coagulant used is preferably 10 to 1000 ppm, more preferably 10 to 300 ppm, and most preferably 30 to 200 ppm. The amount of each of the anionic polymer and the cationic polymer is preferably 0.1 to 50 ppm, and more preferably 0.1 to 10 ppm, and most preferably 0.1 to 5 ppm. All ppm are by weight in relation to the impure water to be treated.

For combinations 1, 2 and 3 above, where each of the three chemicals are added separately, the following general procedure may be adopted.

(i) A predetermined amount of the first chemical is dosed into the sewage or other impure water through

one or more injection points at a first part of the mixing/flocculation zone and is intimately mixed with the said sewage or other impure water, then:

(ii) A predetermined amount of the second chemical is dosed into the sewage or other impure water through one or more injection points at a second part of the mixing/flocculation zone and is intimately mixed with the said sewage or other impure water, and then:

(iii) A predetermined amount of the third chemical is dosed into the sewage or other impure water through one or more injection points at a third part of the mixing/flocculation zone and is intimately mixed with the sewage or other impure water.

(iv) A predetermined amount of the sludge removed from the solids separating zone is recycled to the mixing/flocculation zone, and is dosed into and intimately mixed with the sewage or other impure water. The location of the sludge recycle point in the mixing/flocculation zone and the quantity recycled is site specific and depends on the design parameters as previously described herein.

(v) The time interval between the addition of the first chemical and the second chemical or between the second chemical and the third chemical in the mixing/flocculation zone is site specific and depends on the design parameters as previously described herein.

(vi) The time interval between the addition of the recycled sludge and either the preceding or subsequent chemical in the mixing/flocculation zone is site specific and depends on the design

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parameters as previously described herein.

(vii) The degree of mixing required in the mixing/flocculation zone is site specific and depends on the design parameter are previously described herein.

(viii) The total retention time in the mixing/flocculation zone and the separating zone is site specific, and depends on the design parameters as previously described herein.

For the above combination 1, we have found that in some cases it may be more beneficial to inject any or all of the chemicals in two or more locations into the impure water, but maintaining the essential sequence as previously described. The sludge recycle rate can vary from 1-20% of the impure water flowrate, but is preferably at a flowrate of about 10%.

The sludge can be recycled to the incoming impure water at various locations, the best location being found by site trials.

We have found that the total retention time (mixing and sedimentation) of approximately 30 minutes is satisfactory, but can be reduced below 20 minutes if required.

The time interval between successive chemical doses (different chemicals) can vary, e.g. from just a few seconds up to about 8 minutes, but generally a 5 minute interval or less has been found satisfactory.

The upward velocity in the sedimentation tank can vary, e.g. from 10-20 metres per hour.

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For combinations 4 and 5 above, where an inorganic coagulant is mixed in one container with one of the polymers and then dosed into the sewage or impure water as one homogeneous mixture and then the other polymer is dosed into the sewage, the following general procedure is adopted:

(i) A predetermined amount of the inorganic coagulant and one of the polymers is mixed in one container and dosed as one homogeneous mixture into the sewage or other impure water through one or more injection points at a first part of the mixing/flocculation zone and is intimately mixed with the sewage or other impure water, and then

(ii) A predetermined amount of the other polymer (i.e. of opposite charge to the polymer in Step (i) above) is dosed into the sewage or other impure water through one or more injection points of a second part of the mixing/flocculation zone and it is intimately mixed with the said sewage or other impure water.

(iii) A predetermined amount of the sludge removed from the separating zone is recycled to the mixing/flocculation zone and is dosed into and intimately mixed with the sewage or other impure water. The location of the sludge recycle point in the mixing/flocculation zone and the quantity recycled is site specific and depends on the design parameters as previously described herein.

(iv) The time interval between the addition of the homogeneous mixture of the first two chemicals (i.e. an inorganic coagulant and a polymer) and the third chemical i.e. the polymer of opposite charge to that mixed with the inorganic coagulant in the mixing/flocculation zone is site specific and

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intimately mixed with the interim pretreated sewage to provide chemically treated effluent.

The chemically treated effluent may be supplied to a separating zone wherein the chemically treated effluent and sludge are separately removed. A predetermined amount of sludge is recycled back to the mixing/flocculation zone.

In another method according to the present invention, high molecular weight cationic polymer is added to and intimately mixed with the sewage to provide pretreated sewage, then an inorganic coagulant such as alum is added to and intimately mixed with the pretreated sewage to provide an interim pretreated sewage; then anionic polymer is added to and intimately mixed with the interim pretreated sewage to provide chemically treated sewage. Then the chemically-treated sewage is supplied to a separating zone wherein chemically-treated effluent and sludge are separately removed. A predetermined amount of sludge is recycled back to the mixing/flocculation zone.

In another method according to the present invention, the inorganic coagulant (e.g. alum or ferric chloride) is mixed in the one container with the cationic polymer to form a homogeneous mixture which is then added and intimately mixed with the sewage to provide an interim pretreated sewage; then at a later time an anionic polymer is added and intimately mixed with the interim pretreated sewage to provide chemically-treated sewage. The chemically-treated sewage is supplied to a separating zone wherein the chemically treated effluent and sludge are separately removed. A predetermined amount of sludge is recycled back to

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the mixing/flocculation zone.

In another method according to the present invention, the inorganic coagulant (e.g. alum or ferric chloride) is mixed in the one container with the anionic polymer to form a homogeneous mixture which is then added and intimately mixed with the sewage to provide an interim pretreated sewage; then at a later time a cationic polymer is added and intimately mixed with the interim pretreated sewage to provide chemically treated sewage. The chemically treated sewage is supplied to, a separating zone wherein the chemically treated effluent and sludge are separately removed. A predetermined amount of sludge is recycled back to the mixing/flocculation zone.

In some cases it may be advantageous to introduce one or more of the treatment chemicals and two or more locations in the water to be treated, provided that one of the essential sequences of the invention is maintained.

The amount of predetermined sludge recycled back in the process is typically of the order of 1 to 10%, although rates of 20% or more can be used. This percentage may vary depending on the quality of the influent and the desired effluent quality. It may be recycled to the influent or various locations, the best location being found by site trials.

Table 1 sets out the results of numerous tests carried out on a mixture of sewage and industrial effluent, using an inorganic coagulant (alum), followed by an anionic polyelectrolyte, followed by a cationic polyelectrolyte.

These results indicate that the method of this

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invention is suitable for producing an exceptionally high quality effluent which heretofore was known in the field of water treatment, considering the low overall retention time and the speed of settling of the floc.

The method also results in a very high level of microorganism removal. A sample of raw sewage was found to have a total coliform bacteria count of over 1,800,000 per 100mls, and the treated effluent produced by the method of this invention had a coliform count of only 5500 per 100mls, representing a removal efficiency of over 99.7%.

The same effluent, when passed through a commercially available ultraviolet radiation system had the coliform count reduced from 5500 to 350 per 100mls. Other results have indicated total coliform counts as low as 5 per 100mls after irradiating effluent following the method of this invention.

This is very important advantage of the invention, because it offers a realistic option instead of chlorine for the disinfection of effluents, which are known to cause the formation of chlorinated hydrocarbons, some of which could be carcinogenic.

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TABLE 1

Inorganic Coagulant	Anionic Polymer	Cationic Polymer	Influent Turb.	Effluent Turb.	Removal Efficiency
mg/l	mg/l	mg/l	NTU.	NTU.	%
196	1.00	1.46	76.2	0.91	98.8
195	0.85	1.32	77.2	0.87	98.9
162	1.06	1.28	205.0	1.04	99.5
163	1.14	1.29	126.0	0.93	99.3
169	1.05	1.28	99.7	0.99	99.0
179	1.24	1.24	117.5	1.01	99.1
185	1.26	1.26	107.1	1.02	99.0
162	0.94	1.01	59.7	1.24	97.9
163	0.94	1.01	58.9	1.26	97.9
169	1.03	1.10	66.8	1.05	98.4
164	0.82	1.04	83.8	1.14	98.6
165	1.17	1.17	174.6	1.34	99.2
170	0.98	1.20	114.8	1.21	98.9
171	1.06	1.22	114.2	1.50	98.7
176	1.07	1.22	94.7	1.47	98.4

Table 1 cont/d...

Inorganic Coagulant	Anionic Polymer	Cationic Polymer	Influent Turb.	Effluent Turb.	Removal Efficiency
mg/l	mg/l	mg/l	NTU.	NTU.	%
163	1.11	0.82	97.4	1.09	98.9
173	1.05	0.98	68.4	0.95	98.6
191	1.11	0.96	75.5	1.24	98.4

CLAIMS

1. A method for the treatment of sewage or other impure water which comprises:

1) adding to said sewage or other impure water in a mixing zone, either all three individually or not more than two premixed together, of:

(a) an inorganic coagulant, (b) an anionic polymer, and (c) a cationic polymer with intimate mixing of the added chemicals with said sewage or other impure water, with the proviso that (d) said inorganic coagulant either alone or with the anionic polymer or the cationic polymer is not added last; and (e) said anionic polymer and said cationic polymer is not premixed and added together, thereby to provide chemically-treated effluent having large, compact, firmly-bonded, substantially-shear resistant and rapidly-separable flocs therein;

2) separating the flocs from the liquid in a separating zone; and

3) removing treated liquid effluent from the separating zone.

2. The method of claim 1, wherein said flocs are separated from said liquid by settling as sludge.

3. The method of claim 2, wherein at least some of said sludge is recycled to said mixing zone.

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4. The method of any preceding claim, which is characterised by the following sequential steps:

first adding the anionic polymer, then adding the inorganic coagulant and finally adding the cationic polymer.

5. The method of any of claims 1 to 3, which is characterised by the following sequential steps: first adding the cationic polymer, then adding the inorganic coagulant, and finally adding the anionic polymer.

6. The method of any of claims 1 to 3 characterised by the following sequence of steps: first adding the inorganic coagulant, then adding the anionic polymer and finally adding the cationic polymer.

7. The method of any of claims 1 to 3, characterised by the following sequence of steps: first adding a mixture of the inorganic coagulant and the cationic polymer, and finally adding the anionic polymer.

8. The method of any of claims 1 to 3 characterised by the following sequence of steps: first adding a mixture of the inorganic coagulant and the anionic polymer, and finally adding the cationic polymer.

9. The method of any preceding claim, wherein said inorganic coagulant is an iron or aluminum compound or salt.

10. The method of any preceding claim, wherein said inorganic coagulant is a alum or ferric chloride.

11. The method of any preceding claim, wherein said anionic polymer is an anionic polyelectrolyte.
12. The method of claim 11, wherein said anionic polyelectrolyte is a polyacrylamide with negative acrylate groups.
13. The method of any preceding claim, wherein said cationic polymer is a cationic polyelectrolyte.
14. The method of claim 13, wherein said cationic polyelectrolyte is a polyamine or an acrylamide.
15. The method of any preceding claim, wherein the amount of said anionic polymer is 0.1 - 50 ppm, the amount of said cationic polymer is 0.1 - 50 ppm, and the amount of said inorganic coagulant is 10 - 1000 ppm.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 87/00549

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁴ According to International Patent Classification (IPC) or to both National Classification and IPC IPC ⁴ : C 02 F 1/52																	
II. FIELDS SEARCHED <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Minimum Documentation Searched ⁷</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; border-bottom: 1px solid black;">Classification System</td> <td style="border-bottom: 1px solid black;">Classification Symbols</td> </tr> <tr> <td style="padding: 5px;">IPC⁴</td> <td style="padding: 5px;">C 02 F</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸</div>			Classification System	Classification Symbols	IPC ⁴	C 02 F											
Classification System	Classification Symbols																
IPC ⁴	C 02 F																
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹ <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; border-bottom: 1px solid black;">Category ⁹</th> <th style="width: 70%; border-bottom: 1px solid black;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 20%; border-bottom: 1px solid black;">Relevant to Claim No. ¹³</th> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">EP, A, 0003327 (PASSAVANT-WERKE) 8 August 1979 see page 1, line 1 - page 4, line 22 --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-3,7,9-14</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">US, A, 4173532 (ENTENMANN'S) 6 November 1979 see column 3, lines 25-28; column 3, line 54 - column 4, line 2; column 6, line 14 - column 7, line 44; column 9, line 64 - column 11, line 5; column 11, lines 12-15, 41-48; column 12, line 35 - column 13, line 5 --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-3,6,9,10, 11,13</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">US, A, 4569768 (THE DOW CHEMICAL CO.) 11 February 1986 see columns 9,10; claims 1,3 --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1,8</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">P,X</td> <td style="padding: 5px;">WO, A, 86/04585 (SULZER-ESCHER WYSS) 14 August 1986 see page 10; claims 1-4,7; figure 1 -----</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-3</td> </tr> </table>			Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	X	EP, A, 0003327 (PASSAVANT-WERKE) 8 August 1979 see page 1, line 1 - page 4, line 22 --	1-3,7,9-14	A	US, A, 4173532 (ENTENMANN'S) 6 November 1979 see column 3, lines 25-28; column 3, line 54 - column 4, line 2; column 6, line 14 - column 7, line 44; column 9, line 64 - column 11, line 5; column 11, lines 12-15, 41-48; column 12, line 35 - column 13, line 5 --	1-3,6,9,10, 11,13	A	US, A, 4569768 (THE DOW CHEMICAL CO.) 11 February 1986 see columns 9,10; claims 1,3 --	1,8	P,X	WO, A, 86/04585 (SULZER-ESCHER WYSS) 14 August 1986 see page 10; claims 1-4,7; figure 1 -----	1-3
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A	US, A, 4173532 (ENTENMANN'S) 6 November 1979 see column 3, lines 25-28; column 3, line 54 - column 4, line 2; column 6, line 14 - column 7, line 44; column 9, line 64 - column 11, line 5; column 11, lines 12-15, 41-48; column 12, line 35 - column 13, line 5 --	1-3,6,9,10, 11,13															
A	US, A, 4569768 (THE DOW CHEMICAL CO.) 11 February 1986 see columns 9,10; claims 1,3 --	1,8															
P,X	WO, A, 86/04585 (SULZER-ESCHER WYSS) 14 August 1986 see page 10; claims 1-4,7; figure 1 -----	1-3															
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>¹⁰ Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>																	
IV. CERTIFICATION <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">Date of the Actual Completion of the International Search</td> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">Date of Mailing of this International Search Report</td> </tr> <tr> <td style="padding: 5px;">20th October 1987</td> <td style="padding: 5px;">- 4 NOV 1987</td> </tr> <tr> <td style="border-bottom: 1px solid black; padding: 5px;">International Searching Authority</td> <td style="border-bottom: 1px solid black; padding: 5px;">Signature of Authorized Officer</td> </tr> <tr> <td style="padding: 5px;">EUROPEAN PATENT OFFICE</td> <td style="padding: 5px;">M. VAN MOL </td> </tr> </table>			Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	20th October 1987	- 4 NOV 1987	International Searching Authority	Signature of Authorized Officer	EUROPEAN PATENT OFFICE	M. VAN MOL							
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO.

PCT/GB 87/00549 (SA 18137)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 23/10/87

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